CHP GUIDE #2: FEASIBILITY SCREENING FOR COMBINED HEAT AND POWER IN MULTIFAMILY HOUSING

Prepared for

U.S. Department of Housing and Urban Development
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Introduction

The U.S. Department of Housing and Urban Development's (HUD) *2002 Energy Action Plan*[1] includes initiative #20: to promote the use of combined heat and power (CHP) in housing. Combined Heat and Power (CHP)--also known as "cogeneration"—is the simultaneous production of two or more useful forms of energy from a single fuel consuming device. The average efficiency of the fossil-fueled power plants in the U.S. is 33% and has remained virtually unchanged for 40 years. This means that two-thirds of the energy in the fuel is lost as heat. CHP systems recycle waste heat and convert it to useful energy, and they can achieve overall efficiencies of close to 80%.

CHP can significantly reduce a multi-family building's annual energy costs. Instead of buying all the building's electricity from a utility and separately purchasing fuel for its heating (mechanical) equipment, most--or even all--of the electricity and heat can be produced for less money by a small on-site power plant operating at a higher combined efficiency.

The type of CHP system commonly applied to multi-family housing uses a device that contains an engine, similar to that found in a car or truck, or a microturbine, that drives a generator to produce electricity. The heat (thermal energy) produced by this process is recovered and used to produce hot water or steam, operate a chiller or serve as a dessicant instead of being exhausted from the engine and transferred through the engine radiator (as in an automobile).

Department of Housing and Urban Development and the U.S. Department of Energy created an Interagency Agreement to help implement the HUD CHP initiative. The tasks identified in the IAA include providing CHP guides for apartment building owners, working with the eight DOE-funded Regional CHP Application Centers(RACs), preparing case studies, undertaking market analysis and promoting peer exchanges on CHP among the managers of housing developments.

For further information, see the following web sites:
DOE- http://www.eere.energy.gov/de
EPA- http://www.epa.gov/chp
USCHPA- http://uschpa.admgt.com/
HUD http://www.hud.gov/offices/cpd/energyenviron/energy/index.cfm
Computer software and text were prepared by Steven K. Fischer, Oak Ridge National Laboratory fischersk@ornl.gov.
The HUD contact for information on CHP is Robert Groberg, Energy Management Officer, Office of Environment and Energy, US Department of Housing and Urban Development, Washington, DC 20410 mailto:robert_groberg@hud.gov

[The software and CHP Guides will be made available on HUD and ORNL web sites.]

For further information on the RAC program, please contact Merrill Smith, USDOE CHP Program Manager, or Patti Garland-ORNL (202-479-0292), Program Technical Assistance, or Ted Bronson-PEA (630-248-8778), Program Technical Assistance.

[1] See www.hud.gov/offices/cpd/energyenviron/energy for a copy of the HUD *Energy Action Plan.*

How do you determine whether it is appropriate to consider installing combined heat and power in multifamily housing? Here are two levels of screening available to owners and managers of apartment buildings

1. The Environmental Protection Agency (EPA) has a simple questionnaire with eleven questions, designed for industry and commercial--including residential--buildings. .No special data inputs are required. (See page 4 for the form.) You will find this questionnaire on the EPA Web site:

http://www.epa.gov/chp/project_resources/qualifier.htm

If three are answered "yes" EPA will offer more detailed analysis. The next step in assessing the potential of an investment in CHP is to have a Level 1 Feasibility analysis performed to estimate the preliminary return on investment. The EPA CHP Partnership offers a comprehensive Level 1 analysis services for qualifying projects and can provide contact information to others who perform these types of analyses. The contact information is included on the EPA Web site.

2. "Cogen Manual" Feasibility Worksheets

For a more detailed analysis the Oak Ridge National Laboratory has created computer software based on the worksheets in the 1989 New York State Energy Research and Development Authority (NYSERDA) "Cogeneration Manual"[2] that will roughly calculate the potential return on investment for installing CHP. The user supplies information from the twelve most recent months utility bill data for cost and level of consumption. The user also supplies information on rates for gas and electricity and other fuels used in the building. This includes the energy charge ($kWh), demand charge ($/kW), standby charges for installed generator capacity ($kW) and any supplemental or fuel adjustment. This data will enable to program to make a coarse screening based on the potential for using the waste heat for domestic hot water. (See page 5.) [3]

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[2] "Cogeneration Manual" prepared for Energy Conservation Division of the New York City Office of Rent and Housing Maintenance under contract to The New York State Energy Research and Development Authority by Hirschfeld and Stone Consulting Engineers, Glen Cove, NY. The original manual had three purposes: It explained the concept of CHP in multi-family buildings. It presented guidelines to evaluate technical and economic considerations. It provided guidelines for equipment installation and operation.

[3] In 2004 (NYSERDA) commissioned the preparation of a new analysis tool to determine the feasibility of CHP in existing multifamily buildings. For further information contact Mark Zuluaga at Steven Winter Associates 203-857-0200 .
ORNL has also prepared for the U.S. Department of Energy a more sophisticated software program, Building Cooling, Heating Power (BCHP). It requires the input of hourly consumption data for the past year. See: http://www.eere.energy.gov/de/pdfs/chp_software_survey_020604_bst.pdf

1. EPA: IS MY BUILDING A GOOD CANDIDATE FOR CHP?

STEP 1	Check the points that apply to your building.

- **Do you pay more than $.08/ kWh on average for electricity (including generation, transmission and distribution)?**
- **Are you concerned about the impact of current or future energy costs on your building?**
- **Is your building located in a deregulated electricity market?**
- **Are you concerned about power reliability? Is there a substantial financial impact to your building or residents if the power goes out for 1 hour? For 5 minutes?**
- **Do you have thermal loads throughout the year (including hot water, chilled water, hot air, steam, etc.)?**
- **Does your building have an existing central plant?**
- **Do you expect to replace, upgrade or retrofit central plant equipment within the next 3-5 years?**
- **Do you anticipate a building expansion or new construction project within the next 3-5 years?**
- **Have you already implemented energy efficiency measures and still have high energy costs?**
- **Are you interested in reducing your building's impact on the environment?**

STEP 2	**If you have answered "yes" to 3 or more of these of these questions, your building may be good candidate**

The next step in assessing the potential of an investment in CHP is to have a Level 1 Feasibility analysis performed to estimate the preliminary return on investment. The EPA CHP Partnership offers comprehensive Level 1 analysis services for qualifying projects and can provide contact information to others who perform these types of analyses.

If you would like EPA's CHP Program Manager to contact you with more information on our technical support services, fill out the form found at:

http://www.epa.gov/chp/project_resources/qualifier.htm

and click "Submit."

2. ORNL SOFTWARE BASED ON NYSERDA 1989 "COGENERATION MANUAL"

This software has been prepared by the Oak Ridge National Laboratory to enable owners of apartment buildings to do an initial screening of the potential for installing combined heat and power (cogeneration) in a building. It is based on the Worksheets from the NYSERDA-NYC 1989 "Cogeneration Manual," (Manual)[4] that roughly calculated the potential return on investment for installing CHP. It has been modified for use in other parts of the U.S.

The original Manual was based on the following assumptions, which have been incorporated into the current software:

1. Recovered heat to be used for domestic hot water only.
2. Net Thermal load is a linear function of May-September fuel consumption.
3. Generator sized to meet calculated net thermal load (implicit correlation of generator efficiency and heat recovery)
4. 7,440 full-load hours per year.
5. First cost is nearly linear function of system size.
6. The user supplies the information on the gas and electric rates. This includes four numbers for the electric rate:
   - 6.1 energy charge $/kWh
   - 6.2 demand charge $/KW
   - 6.3 standby charges for installed generator capacity $/kW
   - 6.4 any supplemental or fuel adjustment charge that the utility adds on $/kWh.
7. The user specifies one number for the cost of natural gas; this can be in $/therm, $/million Btu, $/hundred cubic feet, etc., depending on the selection of units.
8. Demand savings 6 months per year.
9. Annual savings from fuel use for hot water assumed to be 1.84 times May-September fuel use.

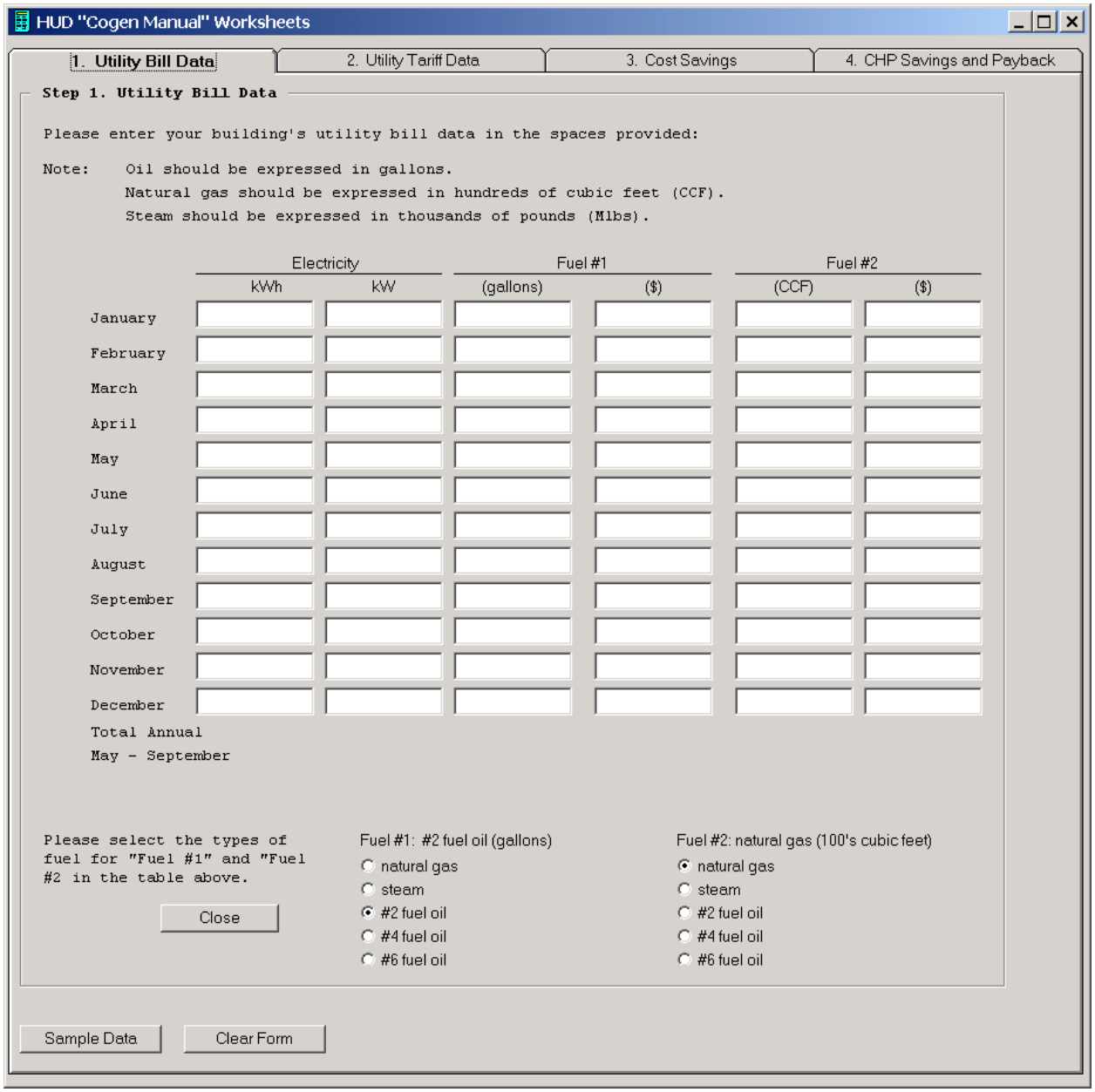
Users should bear in mind that the analysis performed by this program is adequate for a coarse screening to let facility operators know whether or not they should further consider CHP.

[4] "Cogeneration Manual" prepared for Energy Conservation Division of the New York City Office of Rent and Housing Maintenance under contract to the New York State Energy Research and Development Authority by Hirschfeld and Stone Consulting Engineers, Glen Cove, NY. The original manual had three purposes: it explained the concept of CHP in multi-family buildings. It presented guidelines to evaluate technical and economic considerations. It provided guidelines for equipment installation and operations.

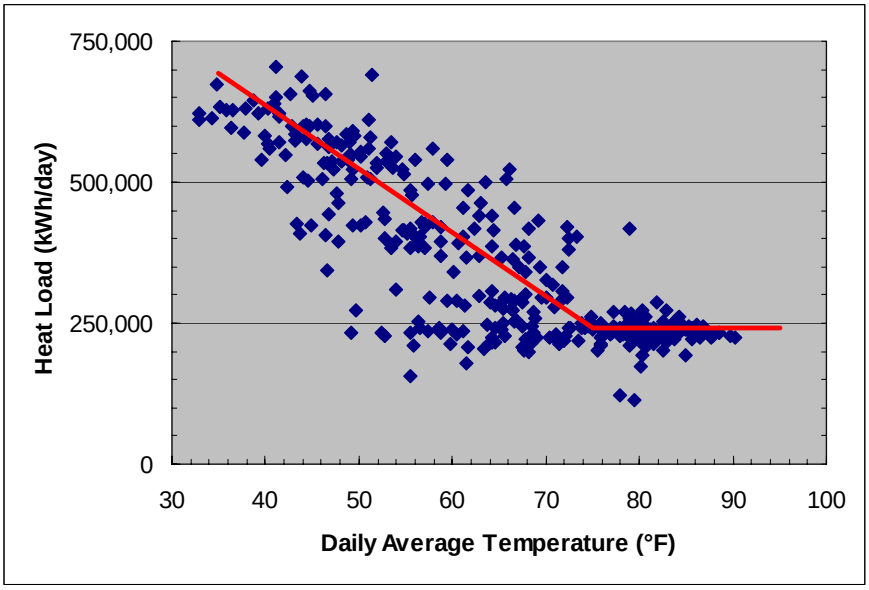
The computerized worksheet contains four screens; two for the input of information and two that display intermediate and final results of the calculations. The user is required to enter information from the facility's12 most recent utility bills in the spaces on the opening screen (shown below). The monthly electricity consumption (kWh) and demand (kW) are used in sizing an on-site generator to provide heat and power so that it does not exceed the amount of electricity that can be used by the apartment building. (Although many people would like to, it rarely makes sense to sell excess power back to the utility because the price paid is so low). In states where net metering is allowed (e.g. CA, CT) the meter may run backwards when the system generates more electricity than it needs. That means that the price "paid" by the utility is the same retail price charged by the utility. This generally is a favorable rate for the CHP system.

The consumption, type, and cost of fuels used on-site are used to estimate hot water loads and potential savings from producing hot water using engine heat. Some facilities use more than a single fossil fuel, perhaps to qualify for interruptible gas rates, so space is provided for two different fuels. Many people will not have to use the second set of columns for fuel data.

The fuel type selections at the bottom of this form are used in the calculations to estimate the amount of space heating and hot air produced by the fuel consumed.


HUD "Cogen Manual" Worksheets
1. Utility Bill Data
2. Utility Tariff Data
3. Cost Savings
4. CHP Savings and Payback
Step 1. Utility Bill Data
Please enter your building's utility bill data in the spaces provided:
Note: Oil should be expressed in gallons.
Natural gas should be expressed in hundreds of cubic feet (CCF).
Steam should be expressed in thousands of pounds (Mlbs).
Electricity
Fuel #1
Fuel #2
kWh
kW
(gallons)
($)
(CCF)
($)
January
February
March
April
May
June
July
August
September
October
November
December
Total Annual
May - September
Please select the types of fuel for "Fuel #1" and "Fuel #2 in the table above.
Close
Fuel #1: #2 fuel oil (gallons)
natural gas
steam
#2 fuel oil
#4 fuel oil
#6 fuel oil
Fuel #2: natural gas (100's cubic feet)
natural gas
steam
#2 fuel oil
#4 fuel oil
#6 fuel oil
Sample Data
Clear Form

The building hot water load is estimated by using the fuel consumption data for May through September, so these numbers are very important. The reasoning behind this is illustrated in the figure below. The blue markers indicate the daily amount of space heating and hot water required at this particular site. The heating requirement is plotted against the average daily temperature on the horizontal axis. The red line is a fit to the data. As the temperature goes up, the heat load decreases to a point and then it remains fairly constant. The space heating requirement decreases and eventually all that is left is the hot water load. The assumption is that fuel consumed in May through September corresponds to the flat portion of the load curve where only domestic hot water is required.

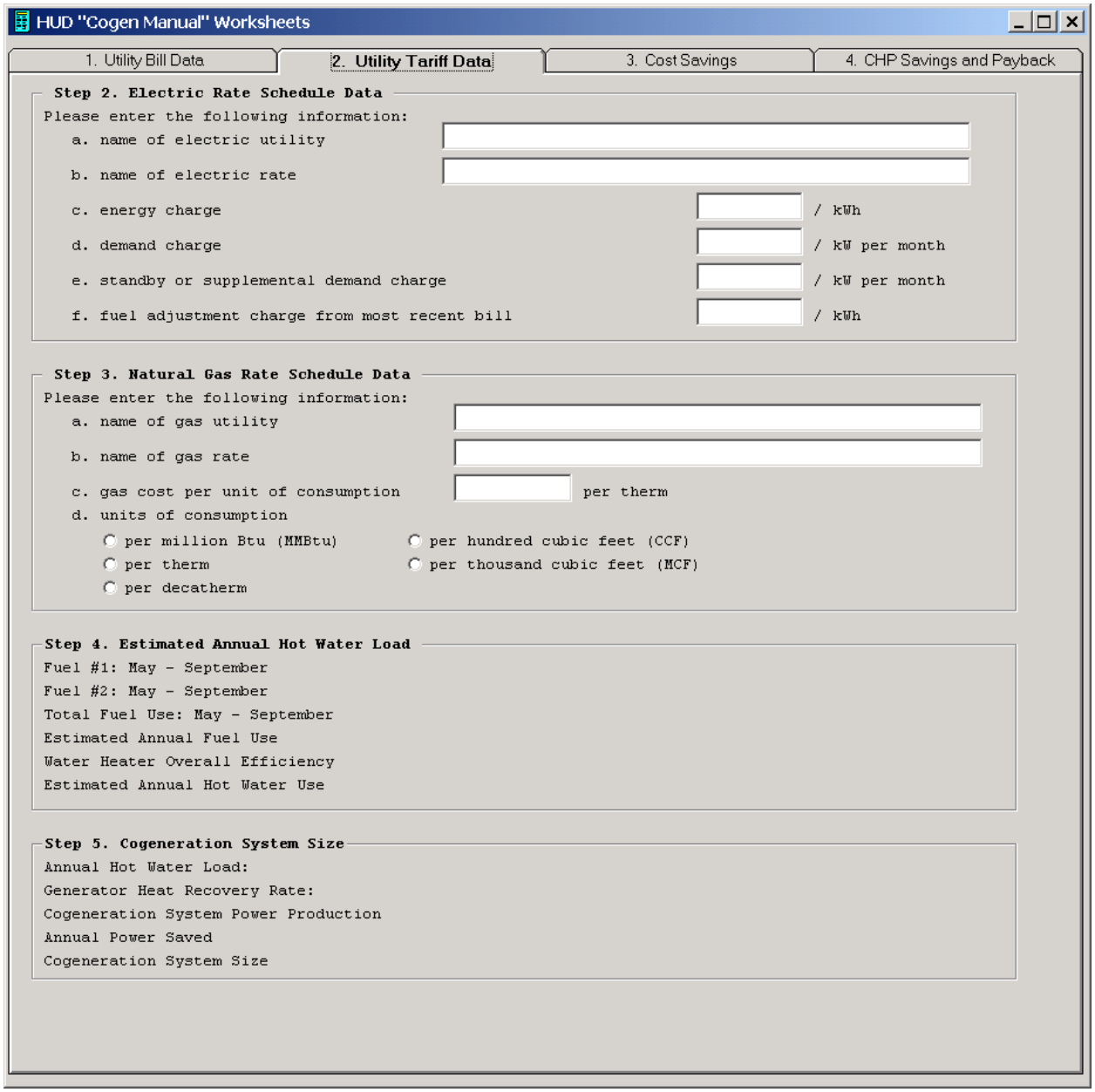


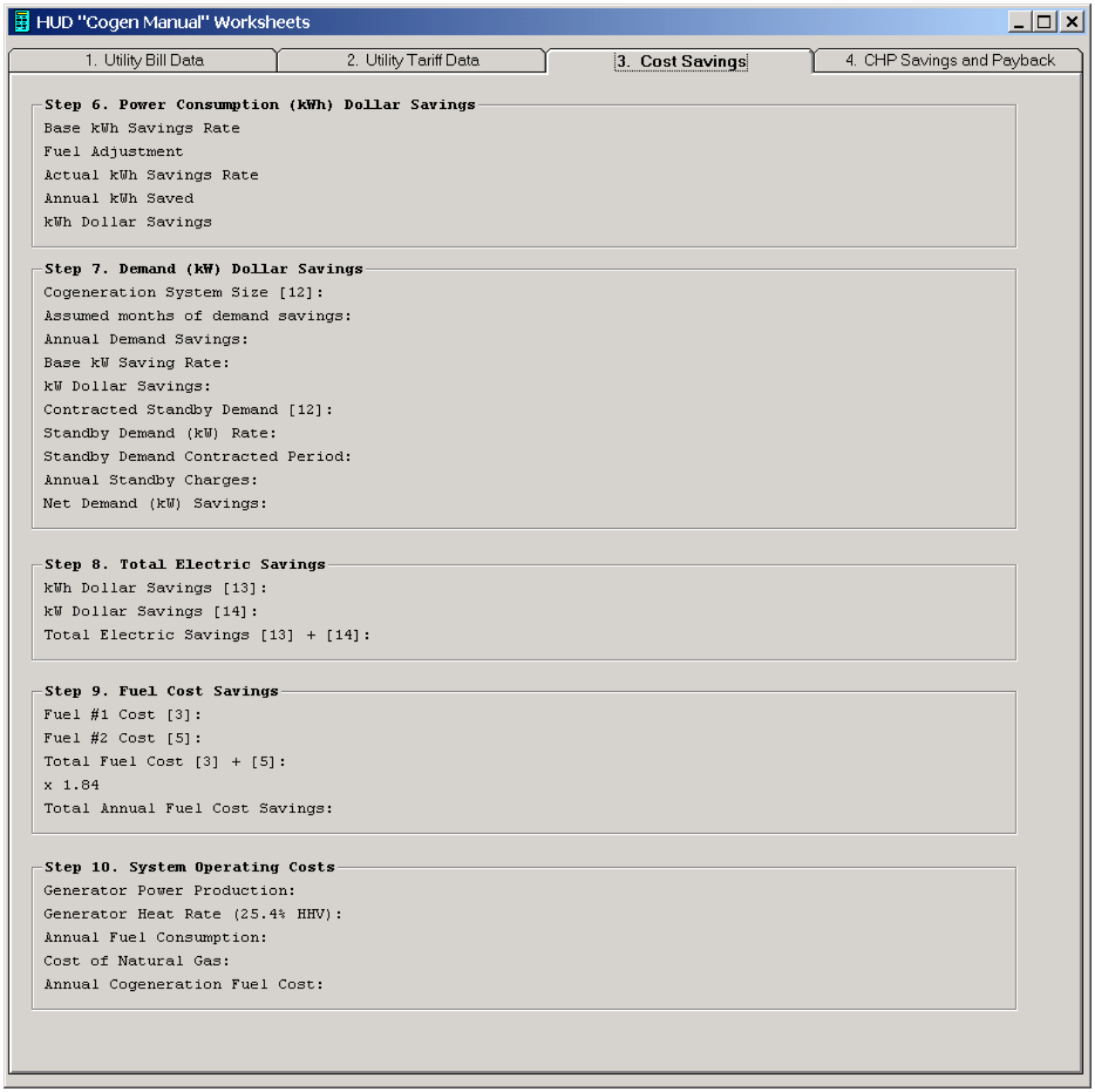
The second screen of the program requires the user to enter some information about the electricity and gas rates at the facility. This form is shown in the figure below. There are blanks for the utility names and rate tariff names; these are helpful in labeling printed output, but they are not required. It is important to provide current information for the electricity charges ($/kWh consumption charge and $/kW demand charge) and the cost of natural gas (it is assumed that any CHP or cogeneration equipment would use natural gas as its primary fuel; almost any other fuel would be difficult to permit because of NOx and SOx emissions). If the electric utility uses a block rate structure where the usage and demand charges are set for multiple levels of consumption (e.g. first 100,000 kWh cost $0.89/kWh, the next 100,000 cost $0.056/kWh) or demand charges vary with time of day, the numbers entered should be for the highest consumption and demand charges seen by the facility.

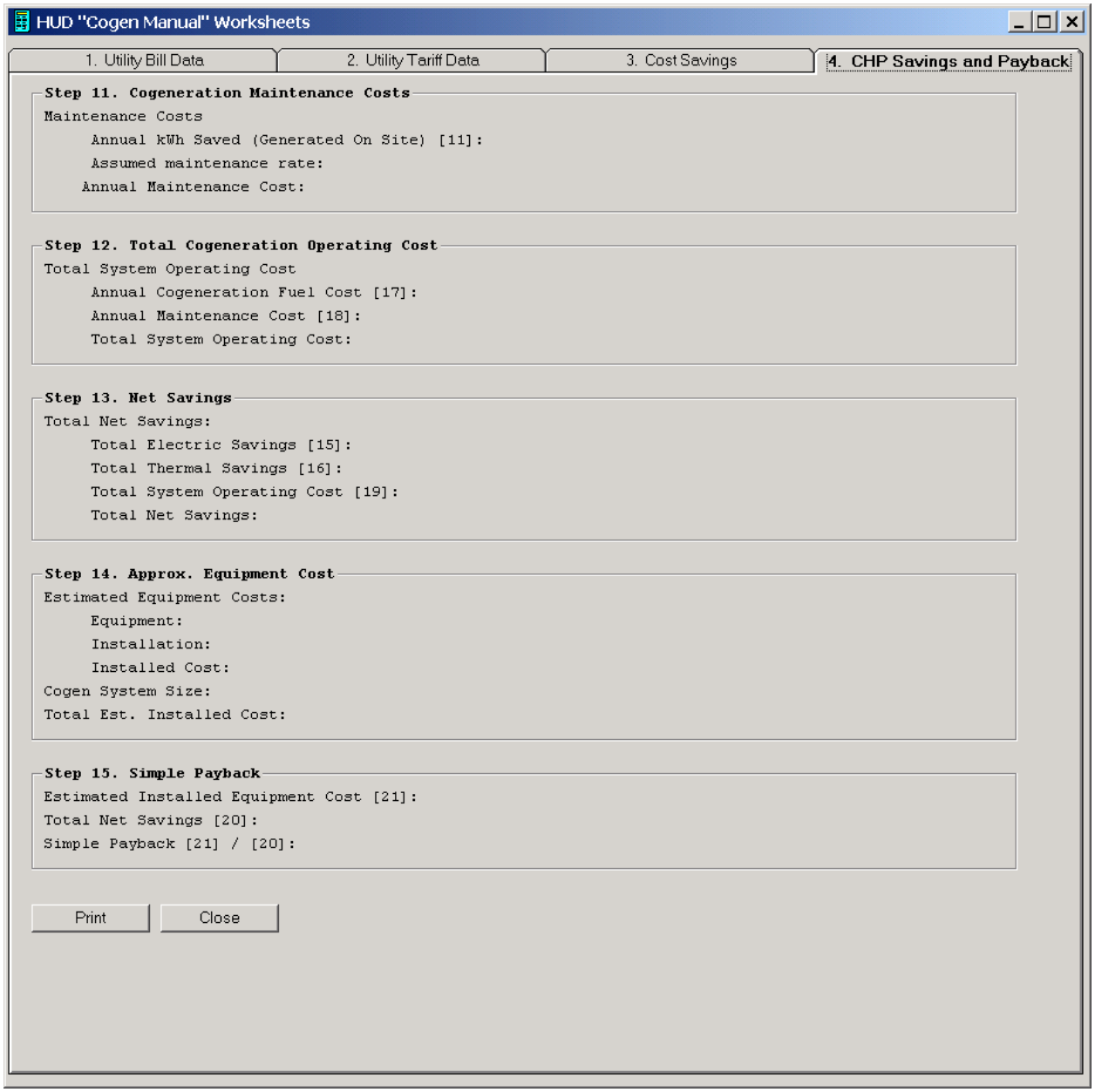
The blocks of information on screen two (“2. Utility Tariff Data”) through screen four (“4. CHP Savings and Payback”) labeled “Step 4” through “Step 15” present the intermediate and final results of the calculations using the data provided. These steps do not require any information from the user.

The numbers in brackets on the right side of some of the lines correspond to similar notations in the original NYSERDA worksheet and do not have any particular significance to the user. They are referenced in some of the row labels to explain how the calculations are performed.

Samples of the third and fourth screens are included on the next two pages.




HUD "Cogen Manual" Worksheets
1. Utility Bill Data
2. Utility Tariff Data
3. Cost Savings
4. CHP Savings and Payback
Step 6. Power Consumption (kWh) Dollar Savings
Base kWh Savings Rate
Fuel Adjustment
Actual kWh Savings Rate
Annual kWh Saved
kWh Dollar Savings
Step 7. Demand (kW) Dollar Savings
Cogeneration System Size [12]:
Assumed months of demand savings:
Annual Demand Savings:
Base kW Saving Rate:
kW Dollar Savings:
Contracted Standby Demand [12]:
Standby Demand (kW) Rate:
Standby Demand Contracted Period:
Annual Standby Charges:
Net Demand (kW) Savings:
Step 8. Total Electric Savings
kWh Dollar Savings [13]:
kW Dollar Savings [14]:
Total Electric Savings [13] + [14]:
Step 9. Fuel Cost Savings
Fuel #1 Cost [3]:
Fuel #2 Cost [5]:
Total Fuel Cost [3] + [5]:
x 1.84
Total Annual Fuel Cost Savings:
Step 10. System Operating Costs
Generator Power Production:
Generator Heat Rate (25.4% HHV):
Annual Fuel Consumption:
Cost of Natural Gas:
Annual Cogeneration Fuel Cost:



Users should bear in mind that the analysis performed by this program is adequate for a coarse screening to let building operators know whether or not they should consider CHP seriously. Discouraging results--a long payback--may save building owners and operators time and effort by eliminating CHP as a viable option for their building. Despite the payback calculated, some CHP developers may reach other conclusions. In any event, encouraging results are only a prelude to a more rigorous analysis to be performed by engineering professionals using much more detailed information on building heating and electricity loads and CHP equipment.

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